

WASTE COMPLIANCE & ENFORCEMENT &  
RELEASE PREVENTION  
BUREAU OF DISCHARGE PREVENTION

GUIDE TO  
VAPOR RECOVERY UNITS  
(VRU)

## **VAPOR RECOVERY UNITS** **CONTAINMENT SYSTEMS**

### **Introduction**

This document on vapor recovery units (VRU) has been prepared to assist our bureau's verification and review staff in evaluating a VRU's containment system.

Vapor recovery units are used when gasoline and other volatile products are pumped into or out of a storage tank, tank car, tank truck or ship.

Most if not all vapor recovery units are packaged units and consist of two types; a refrigeration type and an adsorption/absorption type.

The adsorption/absorption type appears to be the one most preferred, presently. Recent changes made in refrigeration units is, however, bringing increasing attention to the refrigeration method of vapor recovery. You will find below a description of each unit and an attached flow diagram of each.

### **Refrigeration Type**

Vapors first enter a knockout tank where condensate drops out and the vapors pass through. The condensate in the knockout tank is returned to the product storage tank. The vapors enter the vapor recovery unit and are chilled to 34°F to remove as much vapor as possible. The coolant used in most of the present units is glycol.

The vapor then enters the top section of the condensate coil where moisture and hydrates are removed at a very low temperature between -100°F and -120°F. This extreme chilling is accomplished with a cascade foam refrigeration scheme. The "cleaned" vapors are then allowed to vent into the atmosphere and the collected condensed hydrocarbons are decanted.

The recovered product is pumped from the decanter to a storage tank in the terminal. The removed moisture is sent to the in-house water treatment system before it is allowed to be released into the environment. If there is no in-house water treatment facility an oil water separator may be installed.

Once every 24 hours, the main chilling coil is defrosted to eliminate any icy build up which would tend to impede the free-flow of Volatile Organic Vapors (VOC) across the chilling coil. This defrost operation is scheduled to coincide with the minimum loading activity period for the facility. The Vapor Recovery Unit is illustrated on the next page.

**Please Note:** The refrigeration method lost favor because it could not meet more stringent air pollution standards set by the EPA; no more than 10mg/liter of hydrocarbon. This condition of not meeting the new standards has been improved in that the refrigeration system has been modified. By the combination of a modified mechanical system and liquid nitrogen for the coolant the refrigeration unit can now bring the temperature down to as low as -200°F. At -200°F, the hydrocarbon removal is such that the EPA's pollution standards are met. It is anticipated that the cooling modification will reestablish refrigeration units as the favored method of vapor recovery.



### **Adsorption/Absorption Type Unit**

This describes an adsorption/Absorption Gasoline Vapor Recovery Unit. The vapor first enters a knockout tank where the condensate collected is delivered to an absorber tower recycle line. Hydrocarbon vapors enter the VRU into one of two carbon absorbers. The hydrocarbon-air mixture flows up through the absorber where the bulk of the hydrocarbons are adsorbed. The air continues through the carbon absorber and is vented to the atmosphere. The saturated carbon is then desorbed by employing vacuum regeneration of 27.5"Hg vacuum, while the second carbon absorber is receiving the hydrocarbon-air mixture generated in the transport loading activity. The purpose of regeneration is to restore the carbon to a level where it will effectively absorb hydrocarbons again. The two carbon adsorbers alternate between adsorption and regeneration at 15 minute intervals.

When a carbon adsorber is in the regeneration mode, a liquid ring vacuum pump pulls the hydrocarbon from the carbon. The rich hydrocarbon vapors from the carbon adsorber are mixed with the vacuum pump seal fluid and are discharged to an absorber/separator.

The liquid hydrocarbons are condensed and separated from the seal fluid in the separator compartment and are discharged back to a holding tank. Any remaining hydrocarbons pass up through the packed absorber tower and are contacted by a fresh stream of gasoline which absorbs most of the remaining hydrocarbons. The small amount of hydrocarbon that is left and then leaves the top of the absorber and is directed back to the carbon adsorber where the whole process is repeated.

The VRU is illustrated schematically on the next page.

The design and diagrams were provided by the John F. Jordan Service Company of Louisville, Kentucky. These descriptions were taken from two brochures prepared for training purposes by the Jordan Company. You will find these brochures in the Bureau Chief's office. Also, contained in the brochures are recommended daily check lists for the units.



## **Containment and Diversion**

As stated in the introduction, the vapor recovery units are generally packaged units installed by a manufacturer's licensee. The units are compact and fit easily on a dock or loading and unloading area of a facility. The size of the knockout tank which is not part of the package is a matter of preference or space allocated for its installation. It can be installed underground or aboveground, again a matter of preference or availability of either space or equipment using a tank that is already installed and available. The knockout tank is usually in front of the VRU.

If the VRU is installed away from other facilities, it is generally installed on a concrete surface curbed to provide secondary containment, the containment capacity need not be very large if the knockout tank is not included. If not curbed a daily inspection must be vigorously adhered to. A volume of less than 100 gallons is all the containment space required. The knockout tank if above ground should have provisions for containment or diversion of any spills the knockout tank may have.

Where the VRU is installed on a concrete surface with other facilities, provisions must be made to contain any leaks or spills that may occur from any of the other facilities.

Knockout tanks stored underground must meet the regulations for underground storage tanks. It is very unlikely that the volume of these tanks will be over 1000 gallons. Beyond the knockout tank, there would be a very small amount of liquid spilled in the event of a rupture in either the refrigeration chiller type or the carbon adsorption/absorption type.

At the refrigerated chiller type liquid would come only from the condensate decanter. In these there would be water at the bottom layer and gasoline in the upper layer. This is a continuous operation with water being sent to a treatment or oil separation system and the VOC to storage. The total capacity of these decanters is around 35 gallons and the tanks are delivered doubled lined. Where no water treatment facility exists an oil water separator maybe installed.

The adsorption/absorption unit would spill very little liquid if a leak should occurred in the system. Any leak that might occur in the system would be of volatile product that would evaporate. If there should be a complete rupture of a pipe anywhere in the unit, spring operated valves placed in the system would cut out flow to the VRU. This is also true of any leaks that may occur, in the event of a complete pipe rupture. A rupture type of accident would produce no more then 200 gallons of volatile product.

## **Summary**

The Vapor Recovery Units (VRU) are almost entirely of two operating types, refrigerated and carbon adsorption/absorption. The first condenses the vapors by passing the vapor through very cold temperatures. The later removes the vapors by carbon adsorption of the hydrocarbon gases.

These units are usually purchased and installed as a package and are installed by companies licensed by the VRU manufacturer. The VRU units range in size from a one gallon per minute facility for the loading of a single tank truck, to a 10,000 barrels (420,000 gallons) per minute unit, facilities are available for the loading of huge tankers or for the simultaneous loading of a number of trucks, cars or ships.

These VRU facilities are assembled with much care being given to safety and pollution prevention. The probability that a leak or spill will occur is minimal and the most one can reasonably expect is 35 gallons of a mixture of water and product from the refrigeration type and volatile product of no more than 200 gallons from the carbon adsorption/absorption type and this would require rupture of a major product feed pipe and malfunction of the automatic valve shut down system.